Test Data
For TIDA-00558
09/18/2015

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1. Design Specifications

Buck Mode

Vin Minimum	**36V**
Vin Maximum	**56V**
Vin Nominal	**48V**
Vout	**12VDC**
Iout	**56A CV Mode Load set at 48V**
Switching Frequency(SMPS)	**150KHz**
Total Power	**672W**
Number of Phases	**2**
Load Distribution Per Phase	**28A**

Boost Mode

Vin Minimum	**9V**
Vin Maximum	**16V**
Vin Nominal	**12V**
Vout	**48VDC**
Iout	**56A CV Mode Load set at 12V**
Switching Frequency(SMPS)	**150KHz**
Total Power	**672W**
Number of Phases	**2**
Load Distribution Per Phase	**28A**

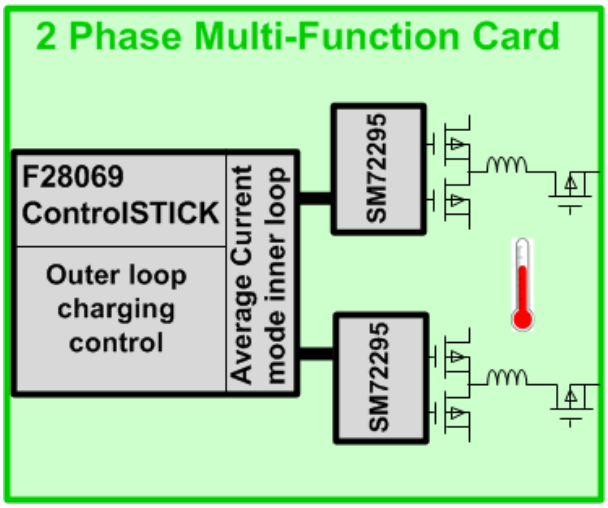
2. Design Description

To address ever tightening fuel economy demands the automotive industry is adopting two battery power systems to facilitate Stop-Start operation in which the internal combustion engine shuts down when stopped or coasting, and automatically restarts when power is applied. Typically a 12V lead acid battery will be used to power many of the car's traditional systems, but a 48V Lithium battery will be used to operate the starter. That same 48V battery will provide a storage reservoir to capture regenerative braking or coast down energy. This creates a need to move power bi-directionally between the two batteries depending on overall system needs.

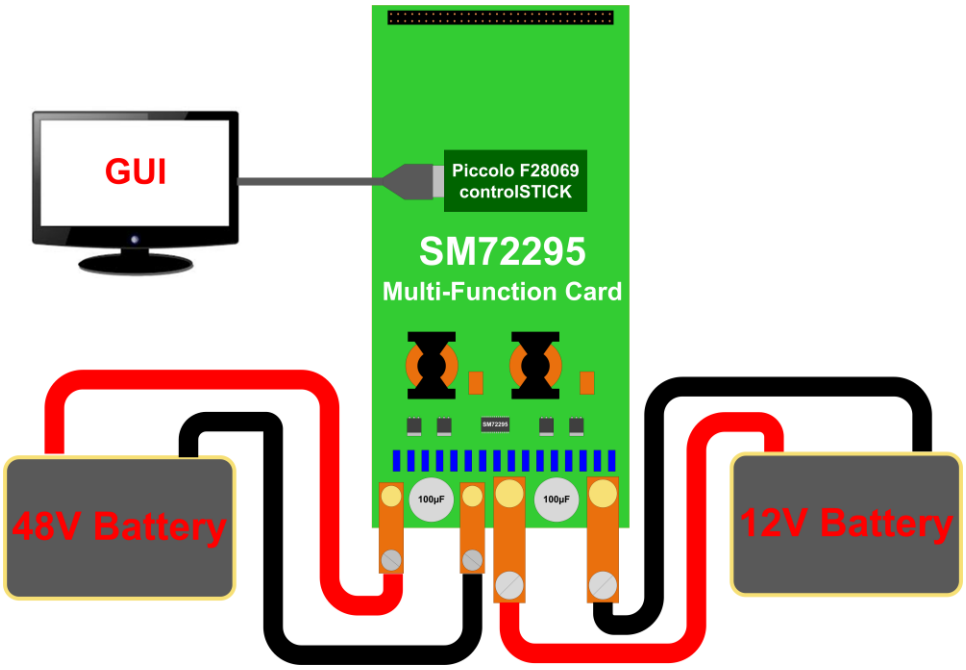
This application note will address deploying the SM72295 in a 48:12 bidirectional charger.

The main features of 48-12 Bi-Directional Power Converter TIDA-00558 are as followed:

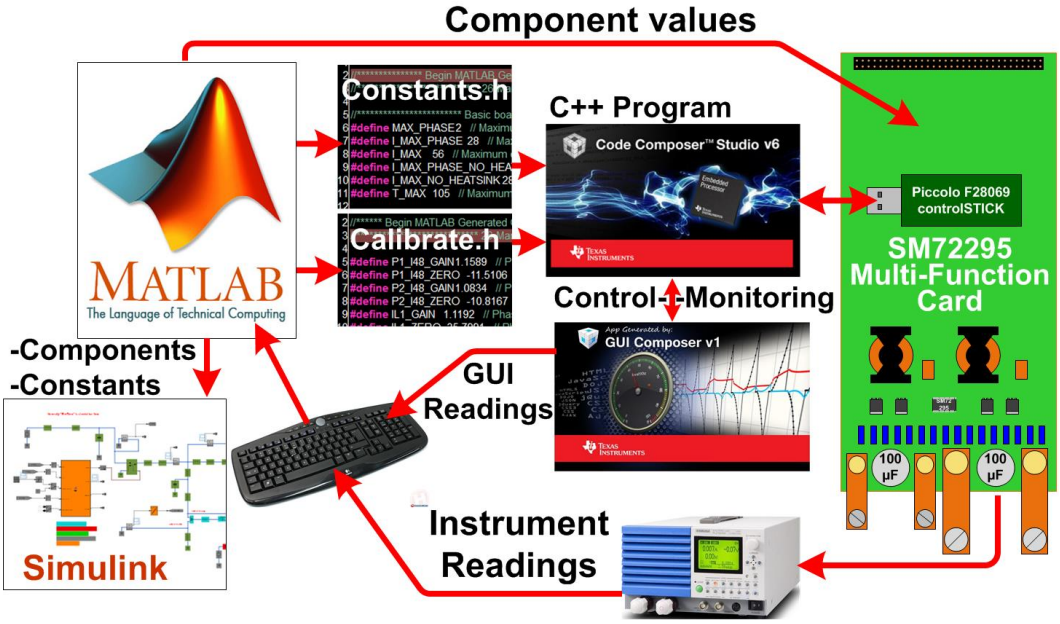
- Nominal 48V-to-12V bidirectional
- 28A per phase
- 150kHz operation
- 2 Phases per card
- One SM72295 per phase
- One C2000 control stick per card
- Average current mode control inner loop
- Voltage mode outer loop
- Firmware OCP & OVP
- GUI monitoring & control of power transfer



System Overview:

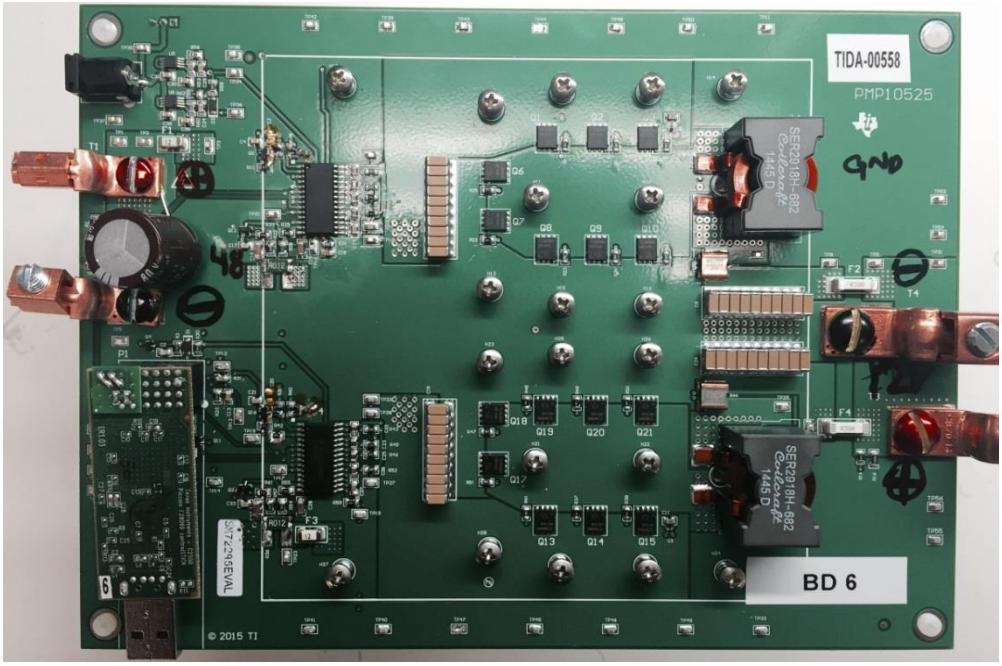


TIDA-00558 Design and Debug Flow:

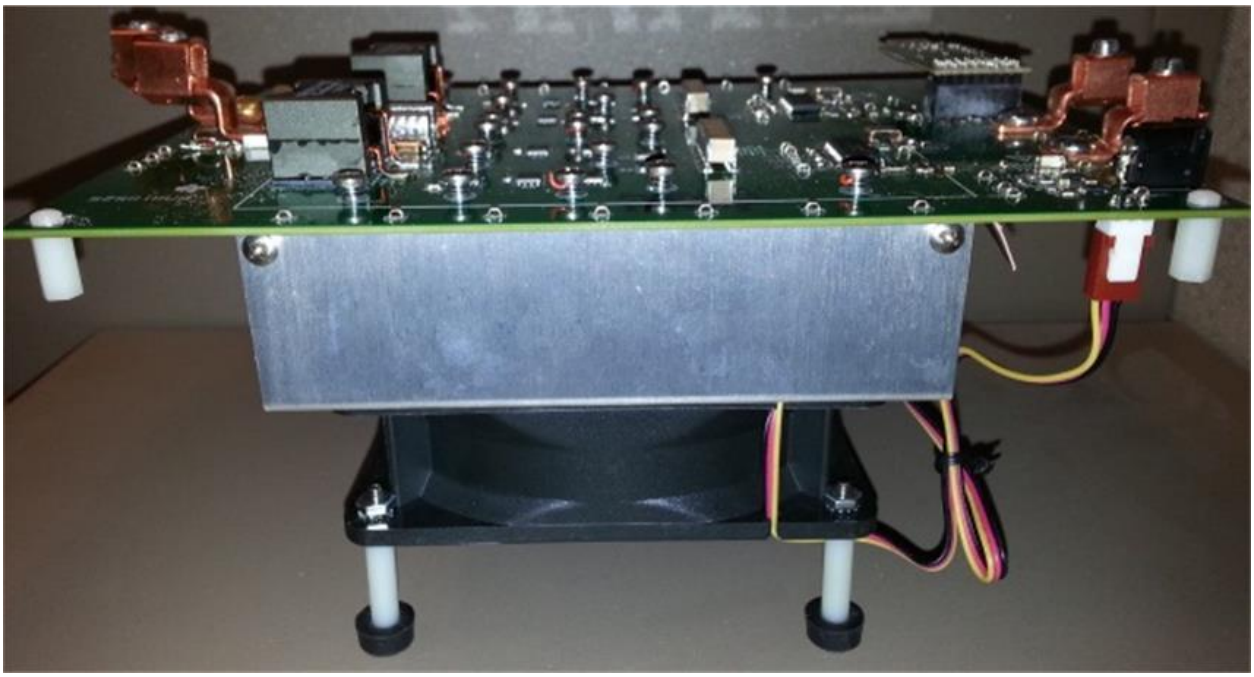


3. TIDA-00558 Board Photos

Board Dimensions: 8660mil *6340mil

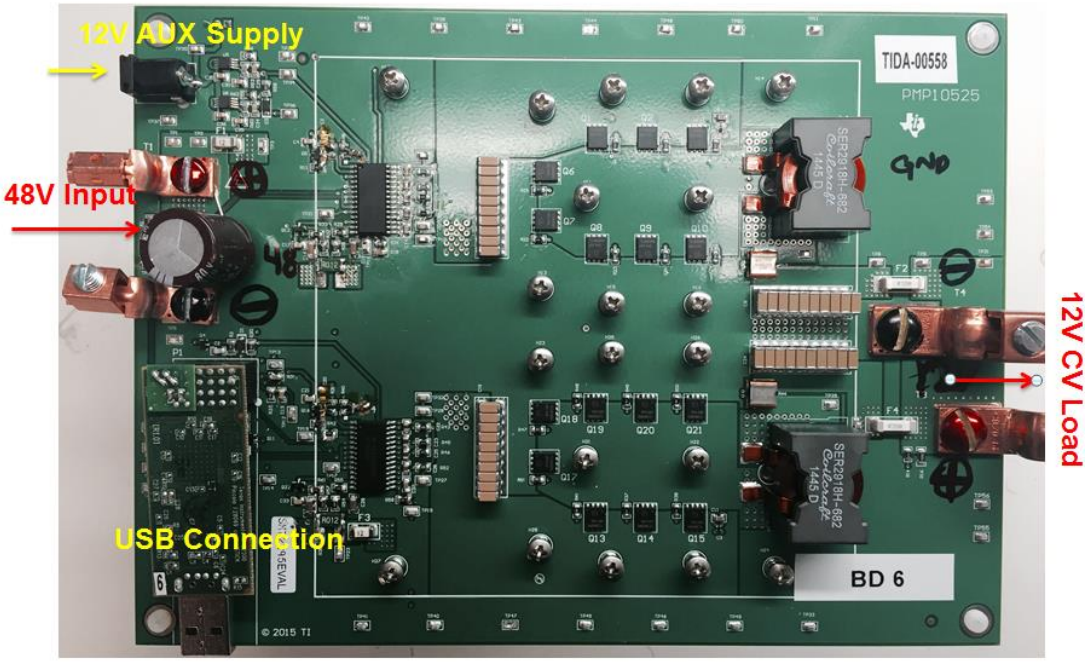


Board Photo (Top)

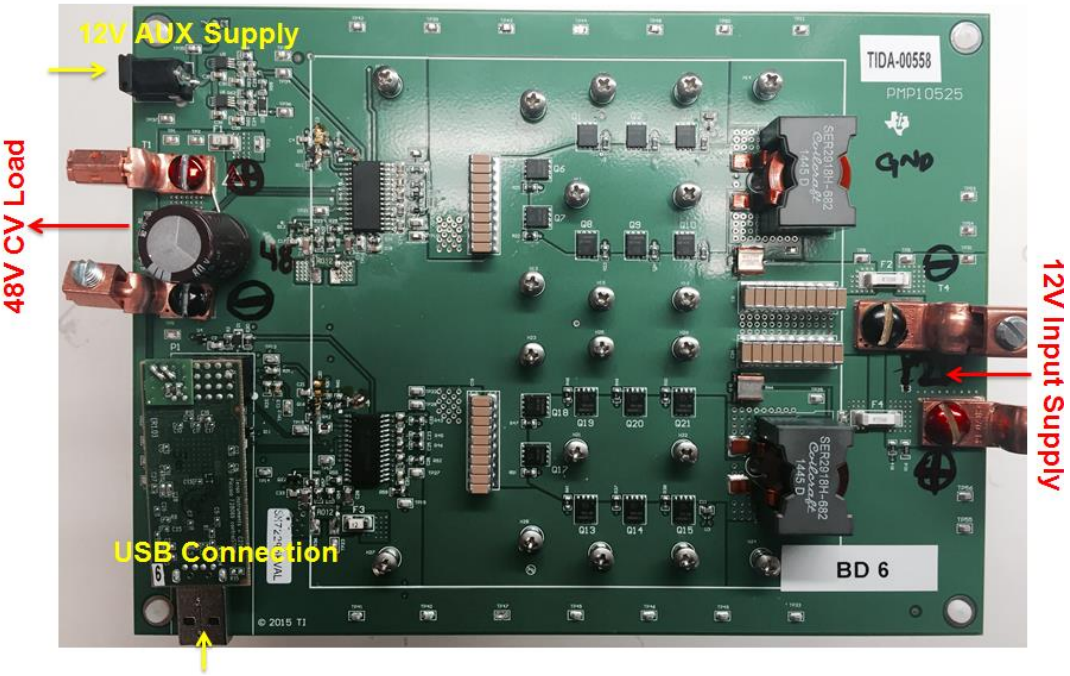


Board Photo (Side View)

3.1 Buck Mode Board Setup



3.2 Boost Mode Board Setup



4 Calibration Results

Load SetPoint	P1_I48_Raw	P1_I48_Standard	P1_I48_Calculated	P1_I48_Error
-28	3.87	-6.666	-6.719	0.795149
-20	5.5	-4.942	-4.96424	0.450006
-15	6.56	-3.818	-3.8231	0.133671
-10	7.64	-2.674	-2.66044	-0.50722
-5	8.75	-1.526	-1.46547	-3.96632
5	11.15	0.945	1.11823	18.33117
10	12.06	2.2	2.097884	-4.64164
15	13.3	3.5	3.432797	-1.92007
20	14.69	4.868	4.929192	1.257033
28	16.61	7.055	6.996155	-0.83409
LoadSet Point	P2_I48_Raw	P2_I48_Standard	P2_I48_Calculated	P2_I48_Error
-28	3.96	-6.52	-6.52523	0.080165
-20	5.59	-4.812	-4.8153	0.068551
-15	6.66	-3.686	-3.69283	0.18531
-10	7.75	-2.552	-2.54938	-0.1026
-5	8.87	-1.392	-1.37446	-1.25993
5	11.17	1.024	1.03832	1.398458
10	12.34	2.278	2.265692	-0.5403

15	13.55	3.547	3.535025	-0.33761
20	14.81	4.845	4.85681	0.243756
28	16.84	6.993	6.986352	-0.09506
Load SetPoint	IL1_Raw	IL1_Standard	IL1_Calculated	IL1_Error
-28	6.8	-29.026	-28.7875	-0.82174
-20	13.76	-21.056	-21.1555	0.472521
-15	18.29	-16.062	-16.1881	0.785226
-10	22.74	-11.151	-11.3085	1.412215
-5	27.29	-6.38	-6.31917	-0.95338
5	36.35	3.61	3.615568	0.154226
10	40.9	8.592	8.604869	0.149784
15	45.43	13.542	13.57224	0.223308
20	49.97	18.532	18.55058	0.100241
28	57.24	26.506	26.52249	0.062228
Load SetPoint	IL2_Raw	IL2_Standard	IL2_Calculated	IL2_Error
-28	6.61	-28.242	-28.0766	-0.58579
-20	13.69	-20.395	-20.4758	0.396007
-15	18.25	-15.451	-15.5803	0.837083
-10	22.8	-10.844	-10.6956	-1.36808
-5	27.33	-5.705	-5.83242	2.233557
5	36.39	3.938	3.894018	-1.11687

10	40.92	8.8	8.757239	-0.48592
15	45.48	13.632	13.65267	0.151603
20	50.01	18.48	18.51589	0.194197
28	57.27	26.256	26.30992	0.205378
V12_Set Point	V12_Raw	V12_Standard	V12_Calculated	V12_Error
9	9	9.1999	9.20938	0.10305
10	9.97	10.2009	10.20164	0.00722
11	10.94	11.1997	11.19389	-0.05185
12	11.9	12.201	12.17592	-0.20556
13	12.92	13.201	13.21932	0.138795
14	13.88	14.199	14.20135	0.016543
V48_Set Point	V48_Raw	V48_Standard	V48_Calculated	V48_Error
36	35.92	36.67	36.67442	0.012045
40	39.87	40.76	40.76281	0.006895
44	43.81	44.847	44.84085	-0.01371
48	47.76	48.936	48.92925	-0.0138
52	51.71	53.019	53.01764	-0.00257
56	55.66	57.099	57.10603	0.012318

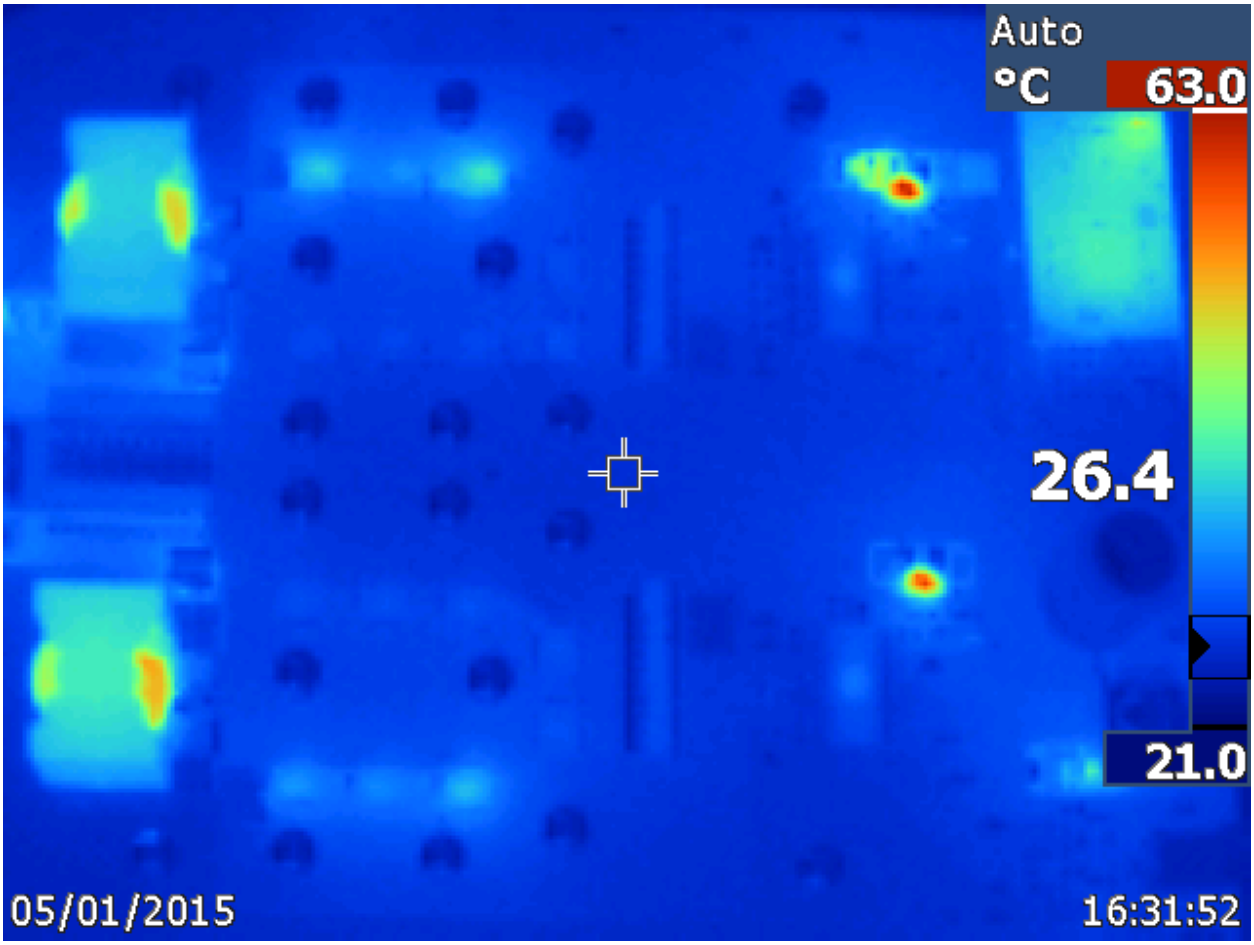
Param	STDEV
P1_I48	6.429999
P2_I48	0.671694
IL1	0.689389

IL2	1.034205
V12	0.122592
V48	0.012075

5 Post Calibration Readings

Phase1 BUCK	Load Set Point (A)	GUI Reading	STND value	% Error		Phase2 Boost	Load Set PT	GUI Reading	Standered Reading Metter	%error
	5	4.99	4.978	0.24048			5	4.99	5.06	-1.40281
	10	9.98	9.972	0.08016			10			
	15	14.97	14.934	0.24048			15	14.97	14.851	0.794923
	20	19.96	19.95	0.0501			20			
	28	27.97	27.928	0.15016			28	27.43	27.52	-0.32811
	56	55.96	55.582	0.67548			56	55.73	55.58	0.269155
V-12	10	12.24		0.16339		V-48	10	47.96	48.14	-0.37531
V-48	10	48.92		-0.01635		V-12	10	12.08	12.035	0.372517
Phase1 BUCK	Load Set Point (A)	GUI Reading	STD value	%error		Phase2 Boost	Load Set Point (A)	GUI Reading	Standered Reading Meter	%error
	5	5.03	5.088	-1.15308			5	4.94	4.88	1.214575
	10						10			
	15	14.99	14.98	0.066711			15	14.96	14.82	0.935829
	20	20	20.024	-0.12			20			
	28	28.02	28.01	0.035689			28	27.84	28.04	-0.71839

6 Thermal Data



IR thermal image taken at steady state with 48Vin and 12Vout@ 56A load (no airflow)-Buck only

7 Efficiency

7. 1. Efficiency of Phase 1 & 2 Buck Mode

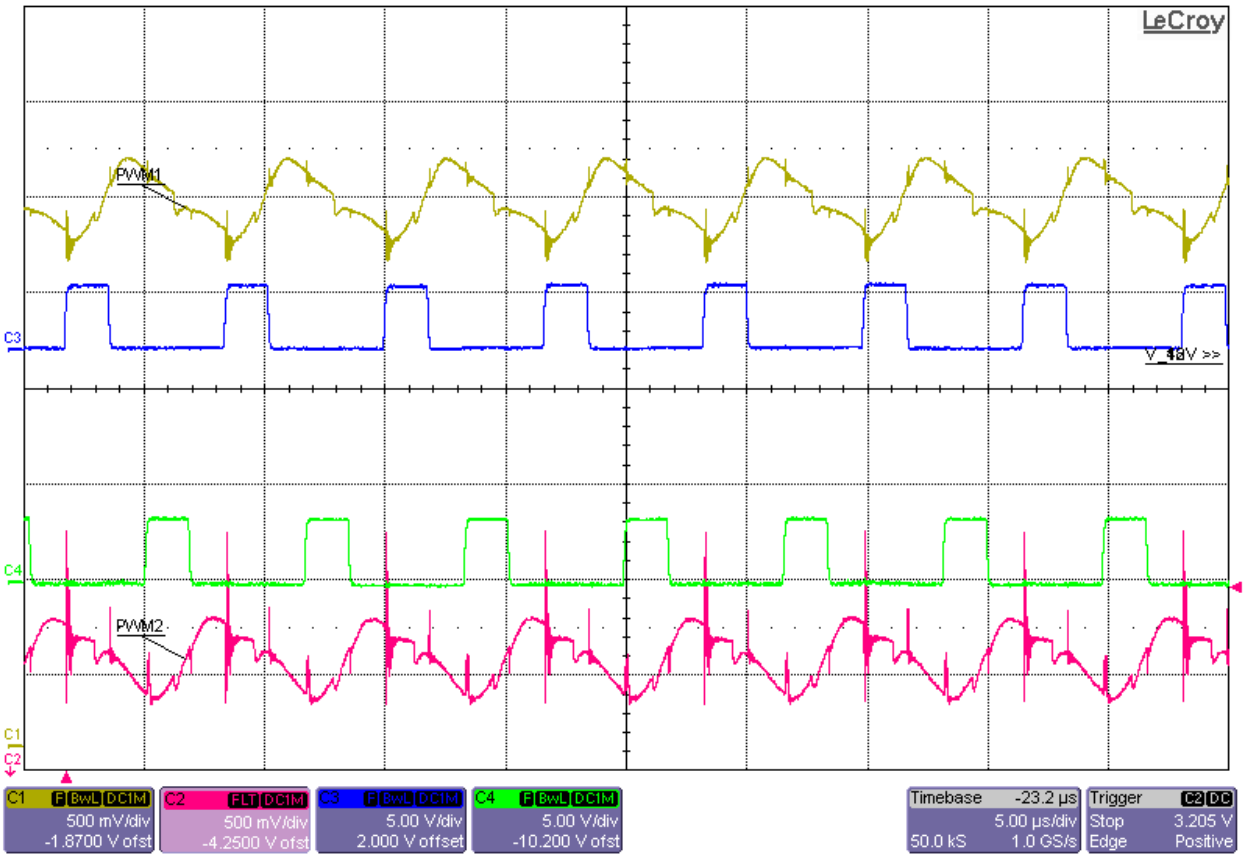
Load Set Point (A)	Power In (W)	Power Out (W)	Efficiency %
Phase 1 - 28A	338.5	324.7	96.42
Phase 2 – 28A	336.1	319.27	95
Phase 1&2 – 56A	672.4	639.25	95.08

7.1 Efficiency of Phase 1 & 2 Boost Mode

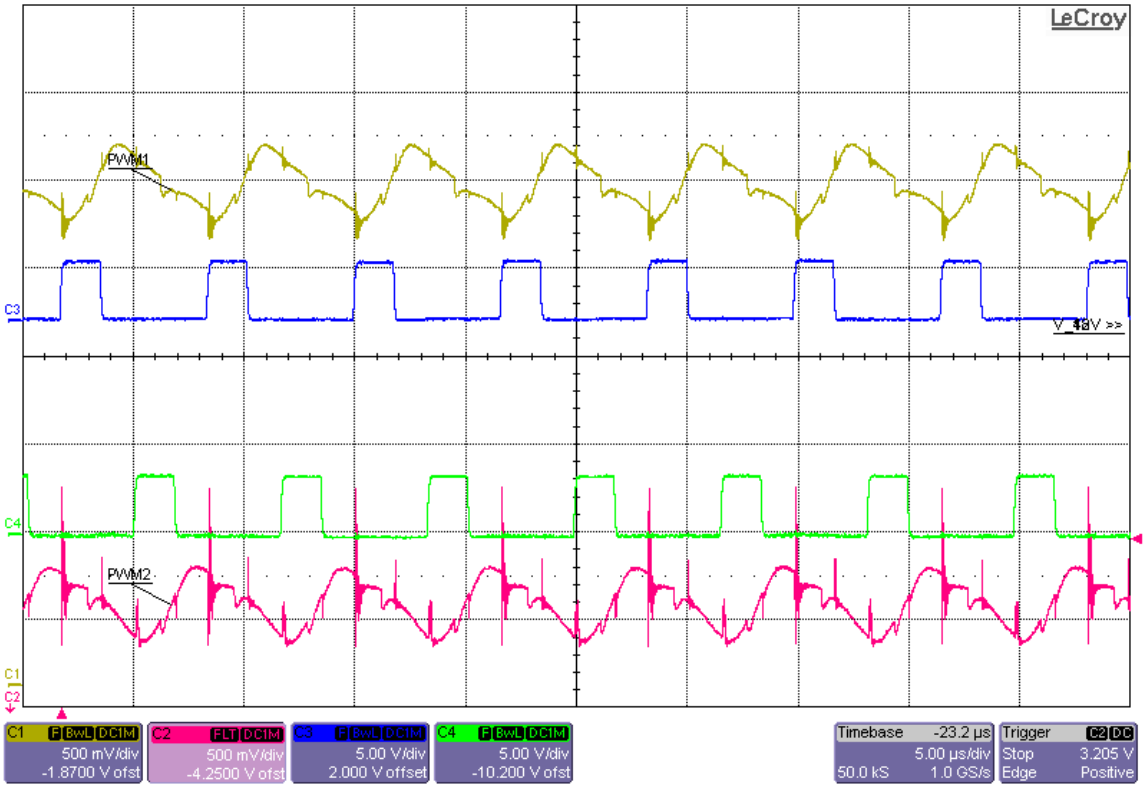
Load Set Point (A)	Power In (W)	Power Out (W)	Efficiency
Phase 1 - 28A	**357.50**	**346.07**	**96.80%**
Phase 2 – 28A	**359.42**	**347.39**	**96.60%**
Phase 1&2 – 56A	**733.3**	**707.54**	**96.52%**

8 PWM Waveforms

8.1 Inductor Current and PWM Waveform – BUCK Mode at 56A Load



8.2 Inductor Current and PWM Waveform – Boost Mode at 56A Load



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